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VOL. 25, SEC. C. JUNE, 1947 NUMBER 3

THE SEASONAL VARIATION IN THE ASCORBIC ACID CONTENT OF EDIBLE WILD PLANTS COMMONLY FOUND IN NEW BRUNSWICK[1]

BY ELIZABETH A. BAIRD[2] AND MURIEL G. LANE[3]

Abstract

The ascorbic acid content in the leaves of 10 wild plants that grow in New Brunswick was determined at approximately two-week intervals from June to September. 'Free' and 'total' dehydroascorbic acid were measured, using the method of Roe. The total ascorbic acid is highest in young green leaves. After the plants have flowered the ascorbic acid decreases. It becomes almost negligible when the leaves have wilted and turned brown. 'Free' dehydroascorbic acid was present in all 10 plants in small quantity. It fluctuated from time to time but remained fairly constant for all the plants during the period of investigation, and was independent of the 'total' value for that plant. The values for ascorbic acid have been measured for ripe strawberries, for fiddleheads, and for several common vegetables over the same summer months. They have been tabulated for comparison with the values of ascorbic acid of the 10 wild plants.

Introduction

A survey was made during the summer of 1946 of the seasonal variation of ascorbic acid in the leaves of 10 different wild plants that grow in New Brunswick.

The plants that were tested were:

1. *Amaranthus retroflexus* L.—amaranthus.
2. *Capsella Bursa-pastoris* (L.) Medic.—shepherd's purse.
3. *Chenopodium album* L.—lamb's quarters.
4. *Oxalis montana* Raf.—wood sorrel.
5. *Portulaca oleracea* L.—portulaca.
6. *Rumex Acetosella* L.—sheep sorrel.
7. *Rumex crispus* L.—curled dock.
8. *Sedum purpureum* Tausch.—live-forever.
9. *Stellaria media* (L.) Cyrill.—chickweed.
10. *Tragopogon pratensis* L.—goat's beard.

These plants were chosen following a preliminary survey during the previous season when the ascorbic acid, carotene, and riboflavin had been determined

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Contribution from the Department of Biology, University of New Brunswick, Fredericton, N.B. This work has been made possible by a research grant to the University from Canadian Cottons, Limited.

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for about 70 plants. They had also been tested for palatability. These 10 plants rated high in the palatability tests and contained moderate to high amounts of ascorbic acid, carotene, and riboflavin (1). Thus it appears that while most of them are classed as weeds, they can now be recommended highly for use on the table, some raw, as salad greens, and some cooked, as spinach. Indeed the vitamin content of many of these plants was much higher than that of many of the vegetables commonly used today.

Methods

The method for estimating ascorbic acid was that of Roe and Oesterling (3). Both 'free' and 'total' dehydroascorbic acid were determined following the original method, that is, with the dinitrophenylhydrazine reagent and incubation for three hours at 37° C. It should be noted here that this method measures only dehydroascorbic acid. However, by means of a second determination, reduced ascorbic acid can be measured also, due to the fact that it may be converted to dehydroascorbic acid by addition of Norit to a metaphosphoric acid extract. The total dehydroascorbic acid then present is determined in the usual way, and the reduced ascorbic acid may be obtained by subtraction of the 'free' dehydroascorbic from the 'total' dehydroascorbic acid. The terms 'free' and 'total' dehydroascorbic acid, therefore, are used in this paper rather than reduced ascorbic acid and dehydroascorbic acid.

The percentage dry weight was obtained for each sample by drying duplicate samples to constant weight in a drying oven at 95° to 100° C., usually about two days.

Sampling

All the species were common in this area. They were all good to eat so as to be of practical value. Some were small plants and some were large; some had heavy foliage and some had very few leaves. They came from different habitats, all within a reasonably small area but from patches that were typical for each species. Some were high in ascorbic acid and some were lower. They represented nine different families. Each plot was observed from early spring and the plants were tested as soon as they became available in sufficient quantity. Plants of the same species were obtained from the same patch to eliminate the effect of soils and microclimate on the ascorbic acid content.

The plants were obtained at approximately two-week intervals starting from the time each species made its first appearance in the spring. The samples were all obtained fresh on the morning of the day on which they were analysed.

Analysis was done on the edible portion; as a rule, only the leaves were used, except when the stems were small and tender, and could be served as an integral part of the green, as in the case of wood sorrel or chickweed.

The leaves were separated from the plants and torn into small pieces by hand. The use of a steel knife was avoided to prevent possible oxidation of ascorbic acid by the metal. After being mixed with the metaphosphoric acid,

they were ground in a Waring Blendor. The leaves from several plants were well mixed to get a representative sample. A 5 to 10 gm. sample was used for each determination.

The vegetables, the fiddleheads, and the strawberries were bought fresh from stores or at the market.

Results

Figs. 1A and 2A show in graphic form the values for 'total' dehydroascorbic acid for the 10 different plants at different dates throughout the season. The values are in milligrams per 100 gm. of dry weight. They were calculated from the fresh weight values and the percentage dry weights.

Many of the plants showed considerable fluctuation of ascorbic acid with fresh weight values, but as the percentage dry weight varied with the weather conditions it was felt that the dry weight values expressed the trend of the seasonal variation better than the fresh weight values.

Figs. 1B and 2B show similarly the values for 'free' dehydroascorbic acid, obtained at the same time as the 'total' values.

Fig. 3 represents the values for 'total' dehydroascorbic acid for strawberries, for fiddleheads, and for several common vegetables, some of which were tested during the summer of 1945 and some during 1946. It has been included for comparative purposes to show the relative values of certain well known vegetables. It has been drawn to the same scale as the previous figures so the graphs for the vegetables and wild plants are comparable.

Discussion of Results

Examination of the results reveals that goat's beard, shepherd's purse, lamb's quarters, and amaranthus (Fig. 1A) all gave the highest values for 'total' dehydroascorbic acid the first time they were examined after the plants had flowered. The flowers were first observed on these plants on different dates, namely, June 10, July 8, July 18, and July 31, respectively. Live-forever showed a steady decrease in ascorbic acid content. Only once, on July 29, were flowering plants examined. The flowering plants gave a slightly higher value than the two previous tests, but in general this species showed a steady decrease.

Five other plants, namely curled dock, wood sorrel, sheep sorrel, portulaca, and chickweed (Fig. 2A) all gave their highest values for the 'total' estimation made just before flowering, followed by a slow but steady decrease. Flowers were first reported on these plants on June 11, June 13, June 20, July 3, and July 18 respectively, and the highest values were obtained two weeks previous to these dates.

The 'total' dehydroascorbic acid varied considerably with different plants but the tendency for all plants was to decrease after flowering.

The plants were not examined daily for the first appearance of flowers. It seems safe to assume, however, that the two-week period marking the

beginning of flowering represents the period of maximum ascorbic acid content for the 10 plants studied. No attempt has been made to correlate the appearance of flowers with ascorbic acid content. Probably both are manifestations of maturity that may or may not be independent of each other.

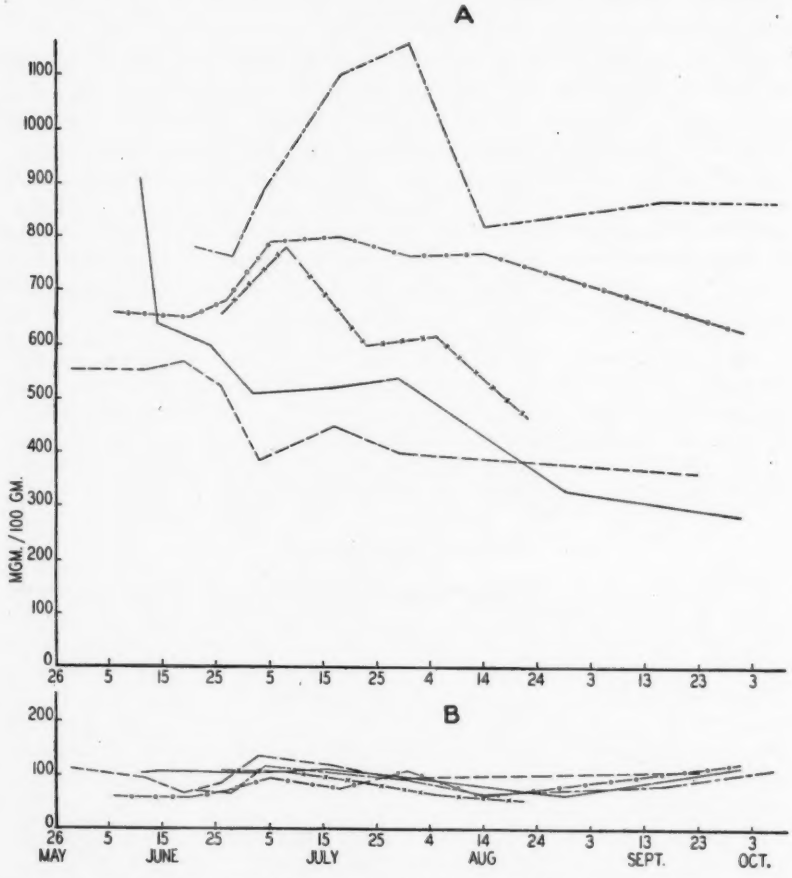

FIG. 1. *Seasonal variation in the ascorbic acid content of live-forever, goat's beard, amaranthus, lamb's quarters, and shepherd's purse. A—'total' ascorbic acid. B—'free' dehydroascorbic acid.*

The values for 'free' dehydroascorbic acid (Figs. 1 B and 2 B) showed much scattering, for all the plants tested. There was little variation between species and even within species no seasonal trend could be observed.

The ratio of 'free' to 'total' dehydroascorbic acid varied from 10 to 25%. This is in agreement with Tuba *et al.* (4) who found that in green plants,

such as pigweed, cabbage, and peas, dehydroascorbic acid exceeded 10% of the ascorbic acid value. The ratio is slightly higher than that found by Roe and Oesterling (3) who reported the dehydroascorbic acid in some green plants to be about 5% of the amount of ascorbic acid.

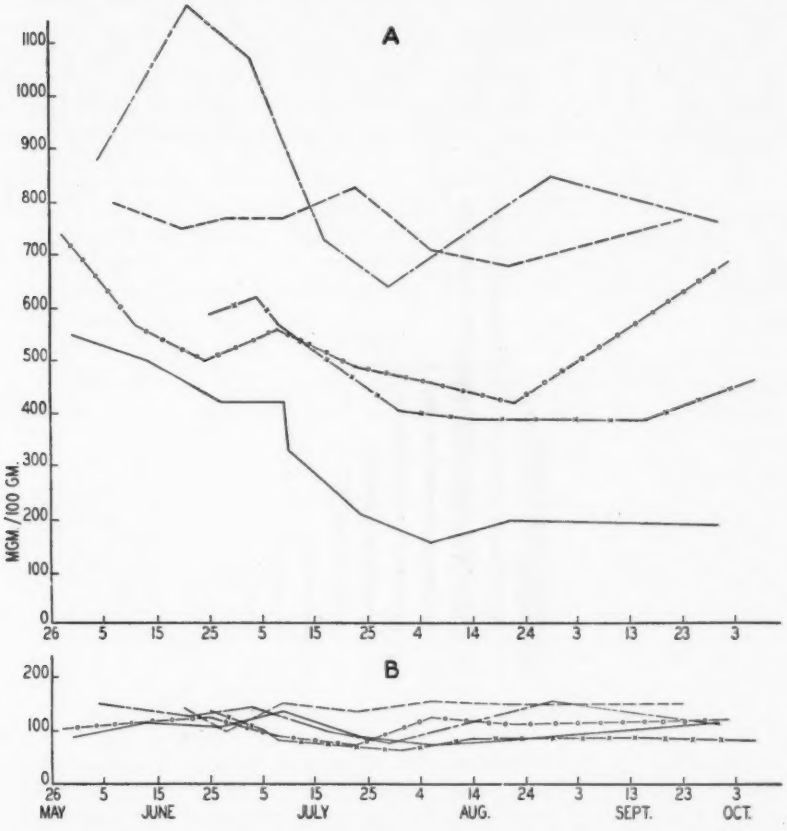

FIG. 2. *Seasonal variation in the ascorbic acid content of sheep sorrel, wood sorrel, portulaca, curled dock, and chickweed. A—'total' ascorbic acid. B—'free' dehydroascorbic acid.*

The dock and the wood sorrel gave slightly higher values than the other plants for 'free' dehydroascorbic acid. They were both highly pigmented after extraction and although blanks were run to make allowance for the colour effect, these two remained noticeably higher than the others. The 'total' extracts, after treatment with Norit, were always colourless.

Although the tendency was for the ascorbic acid to decrease after flowering it must be borne in mind that this was a survey of wild plants from their

natural environment. Hence it was impossible to state the exact age of each individual plant.

For curled dock, for example, the first five samples were obtained from the same patch. By Aug. 29 all these plants had completely died down, so the two last samples were taken from another plot nearby that was known to have started growing later in the season. These two samples, which were still fresh and green when tested, showed an increase over the final samples from the first plot. A sample of shepherd's purse, picked on Aug. 5, that contained plants that had died down and were almost completely brown, gave a very low value of 200 mgm. per 100 gm. It was not included in Fig. 1 A as

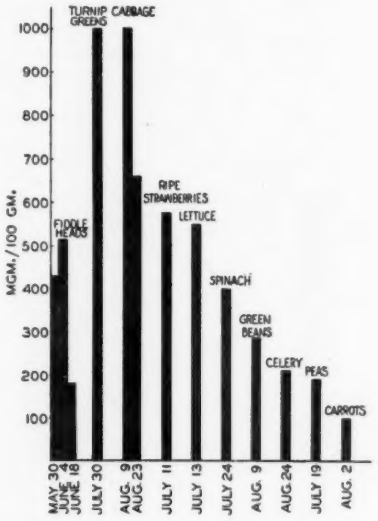

FIG. 3. *'Total' ascorbic acid content of several common vegetables.*

we planned to test only representative samples at different seasons. In the case of wood sorrel the seasonal variation was slight; these plants always appeared to be at about the same stage of development with new flowers appearing constantly.

In view of these observations, the variation would appear to depend on the stage of development. It almost coincided with seasonal variation so that the higher values are obtained early in the summer. However, plants of the same species at the same stage of development, whether early or late, gave approximately the same values for ascorbic acid.

Finally, it appears that the ascorbic acid values of these wild plants compare favourably with those of several common vegetables (Fig. 3). Amaranthus and curled dock, at their best, gave higher values than cabbage or turnip greens. The values found in lamb's quarters, shepherd's purse, wood sorrel,

sheep sorrel, portulaca, and goat's beard were lower than those in cabbage but in the same range as those of lettuce or strawberries and higher than those of spinach or green beans. The amounts in chickweed and live-forever, the two wild plants in which values were lowest, were higher than in celery, peas, or carrots.

This is in agreement with the results of Murray and Stratton (2), who found values for dock to be twice as high as for spinach; shepherd's purse and lamb's quarters about equal to spinach; and chickweed considerably lower.

Fiddleheads, *Onoclea Struthiopteris*, which are commonly used along the Saint John River valley in early spring as a cooked green, contained a moderate amount of ascorbic acid. Like the other plants studied, the amount of 'total' dehydroascorbic acid decreased at the end of their season.

These 10 representatives of the edible wild plants of New Brunswick could be used as a valuable dietary source of ascorbic acid. From the study of the seasonal variation it became evident that they can be most highly recommended for use in the early summer before the garden vegetables become plentiful.

Acknowledgments

The authors wish to acknowledge their indebtedness to Dr. C. W. Argue, Head of the Department of Biology at the University of New Brunswick.

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MEANS OF INOCULATION OF THE DUTCH ELM DISEASE BY *HYLURGOPINUS RUFIPES* EICHH.[1]

By René Pomerleau[2]

Abstract

Investigations on the transmission of the Dutch elm disease were carried out during summer of 1946 in Canada, where the only known vector of the fungus is the native bark beetle, *Hylurgopinus rufipes*. By close observations of young elms, recently and naturally infected with *Ceratostomella Ulmi*, it was found that by boring tunnels through the thin bark of twigs or small branches to the cambium, the adults of this beetle can inoculate the disease to healthy trees.

Of the two known insect vectors of *Ceratostomella Ulmi* (Schwarz) Buis. found in the United States (2), only the native beetle, *Hylurgopinus rufipes* Eichh. occurs in Canada and is associated with this outbreak of the Dutch elm disease.

The apparently rapid spread of the disease in Eastern Canada (7), in the absence of the European beetle, *Scolytus multistriatus* Marsh, draws anew attention to the behaviour of the native beetle, although it is not considered as a very effective carrier of the pathogen in the United States (8). Proof has been given that adults of the European bark beetle can transmit the disease through twig crotch feeding injury (4, 6, 9), whereas the means of spread of the pathogen in the field by the native beetle has been incompletely worked out.

Collins *et al.* (3) found that adults of *H. rufipes*, confined in cages, feed on twigs and trunk of young elm in which they bore holes similar to those produced by *S. multistriatus*. Kaston and Riggs (5) have found in Connecticut bark tunnels that they believe the beetle bores for feeding purposes before it constructs brood galleries in dying parts of elms. Yet neither these authors nor others have demonstrated how in nature the insect introduces the fungus inside the bark of healthy trees.

Since 1945 branches of several tall infected felled trees were closely examined with the purpose of finding feeding injuries produced by *H. rufipes* on twigs. As no scars similar to those made by *S. multistriatus* in the United States were found, we have therefore endeavoured to find, through other methods, the usual way of entrance of the spores. The well known habit of the native insect of finding shelter in the bark of elm during fall (1) has long ago suggested to some American scientists that the fungus may come in contact with xylem by this means. In order to check over this opinion, overwintering cells of the beetle were examined in the bark of several trees located in the heavily

[1] *Manuscript received March 11, 1947.*
Contribution from the Division of Forest Pathology, Department of Lands and Forests, Quebec.

[2] *Director, Division of Forest Pathology, Department of Lands and Forests, Quebec.*

infected area. It has not been possible in any case to trace in the bark of the trunk or large limbs a tunnel chew inward from the cell to the cambial region before emergence.

In order to obtain information on the transmission of contagion to healthy elms in Canada, young elms, just showing the first symptoms of the disease, were selected in 1946 in the vicinity of the towns of Berthierville and Sorel, the centre of the infected area. Some 30 trees answering to these requirements were found, cut down, and carefully studied. Under the bark of most of them, by following the characteristic brown streaks, it was possible to disclose one or several places where the inoculum was left. These marks are always connected to a small tunnel dug by an insect through thin bark. The puncture left on the sapwood by the insect is shallow and of about 1 mm. in diameter (Fig. 1). In most instances they are surrounded by an elliptical dark spot, measuring 4-10 × 3-5 mm. (Fig. 2). Sometimes, when the infection of the vascular system is in its first stage, only a small, faint, brownish discoloration can be seen around the bite (Fig. 3), or the only trace left on the wood by the close passage of the insect is a tiny brown speck.

Several of these spots are to be seen, on the wood of certain trees, especially when the trees are growing close to dying ones or those heavily infested with *H. rufipes*. The tunnels are sometimes numerous in rough parts of the bark (Fig. 4) or near the axil of a twig (Fig. 5). They are short and extend usually to an emergence hole nearby. It is important to mention here that these small channels dug to the sapwood were noticed only on twigs or limbs less than 2 in. in diameter. Hence, one can readily understand that the bark beetle may more easily reach the living xylem and deposit spores on it through the thin bark of branches of this size than through the thick bark of larger branches or trunk. The bark or feeding tunnels, noticed already by Kaston and Riggs (5), from ground line to small limb on elms in Connecticut, do not differ from those we have described here except, at least under conditions that prevail in Canada, that they are sometimes burrowed to the sapwood.

In few instances, the origin of the infection on twigs can only be traced close to a mechanical injury or a dead part due to sunscald (Fig. 6) or canker, along which an insect has succeeded in boring a tunnel to living wood.

In order to ascertain that all the trees studied were infected, samples of twigs were taken near the point of origin of the disease and kept for culturing in the laboratory. Cultures from all these samples have yielded *C. Ulmi*. The fact that adults of *H. rufipes* were often found in such tunnels does not leave any doubt of their responsibility as vector of the disease.

The results of this investigation, carried out in Canada, where the action of the only known vector of the fungus is not hidden by the injuries of the European *Scolytus*, as in the United States, indicate clearly that *H. rufipes* can readily inoculate *C. Ulmi* to healthy elm by boring up tunnels to sapwood through the thin bark of twigs and small branches.

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FIG. 1. *Punctures made by Hylurgopinus rufipes on the sapwood of an elm twig.*

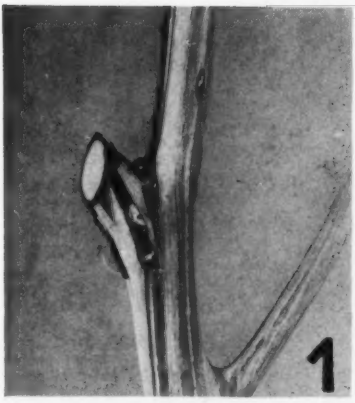
FIG. 2. *Dark spots formed around insect injuries on sapwood of an elm twig.*

FIG. 3. *Faint brownish discoloration around wounds produced by the insect on the sapwood of an elm twig.*

FIG. 4. *Several tunnels bored by the insect in rough part of the bark of an elm twig.*

FIG. 5. *Tunnels dug by the insect near the axil of an elm twig.*

FIG. 6. *Insect puncture on the sapwood near a dead part of an elm twig.*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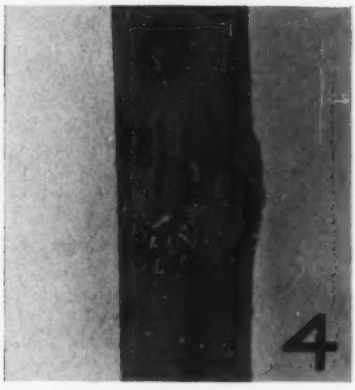
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A STUDY OF THE SPECIES OF *ENTYLOMA* ON NORTH AMERICAN COMPOSITES[1]

By D. B. O. Savile[2]

Abstract

A study of the species of *Entyloma* on North American composites suggests that almost every form can be assigned to one of two phyletic groups. *E. polysporum* contains most of the forms with densely crowded, rather large teliospores and no conidia. *E. Davisii* on *Rudbeckia hirta* and, probably, a fungus on *Lepachys columnaris* are segregated from it. *E. Compositarum* contains most of the forms with smaller, uncrowded spores and abundant conidia. *E. arnicale* and possibly one or two other forms may be regarded as segregates from this species.

Emended descriptions of *E. polysporum* and *E. Compositarum* are given to clarify the differences between these two species. Corrections are also made in the identification of some exsiccati specimens.

Comparisons are made with European forms to the extent that material has been available, but far more study of European specimens is needed to allow assessment of some species.

Species concepts for these fungi are discussed, and criteria are suggested for adequate morphological studies.

The present study had its origin in the observation that the leaf smut of *Gaillardia aristata* agreed more closely with *Entyloma Compositarum* than with *E. polysporum* to which it had been ascribed. Examination of these two species on a number of hosts revealed that they had been widely confused. This confusion seems to have arisen partly from the misnaming of certain specimens in American exsiccati and partly from the inadequacy of the original descriptions. As has already been indicated (Savile, 13, 14), all available Canadian collections on *Gaillardia* are assignable to *E. Compositarum*.

Before discussing the individual collections upon which this study is based, some consideration of the species concept in *Entyloma* is necessary. American mycologists have probably been more prone than European workers to abide by the morphological species concept for parasitic fungi, where such a concept is workable, and to assign designations below the rank of species to those entities that are distinguishable only by host specialization. It must be admitted that a compromise is often necessary where the basis of morphological distinction is meagre. It may be helpful to consider the method rather widely, if tacitly, adopted in the Uredinales, which are perhaps on a sounder taxonomic basis than any other major parasitic group. In very few instances could much progress be made in the identification of a rust if no information on the identity of the host were available. It is common practice to regard morphologically similar rusts as one species if they occur on closely

[1] *Manuscript received February 6, 1947.*

Contribution No. 860 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa.

[2] *Assistant Plant Pathologist.*

related hosts and as distinct species if the hosts are not closely related. Unquestionably some errors are introduced by such a method, but on the whole it has proved to be workable and accurate.

In the Ustilaginales there are fewer morphological characters available than in the Uredinales, owing to the simpler life cycle. Consequently there is a greater temptation to depart entirely from the morphological basis of classification, and some writers, notably Ciferri (4) and the Sydows (19), have separated species almost entirely on the basis of host identity with little or no evidence even of specialization on that host. The concensus of opinion may eventually demand such a narrow species concept; but, in any event, it is desirable that the fullest use be made of such morphological characters as do exist. The present study has repeatedly shown that this requirement has not been fulfilled, and the discussion to follow will show examples both of inadequate descriptions and of disregard of definite morphological distinctions. Ciferri's (5) discussion of the species concept with special reference to the smut fungi contains a good example of the latter failing in the statement: "Under the caption, *Entyloma Calendulae* (Oud.) de Bary, European mycologists included all *Entyloma* living on the members of the Compositae family. On the other hand, American mycologists assigned the same function to *E. Compositarum* Farl. The two species, from the morphological standpoint, are identical". The early students of this genus actually showed much more discrimination than Ciferri suggests, but the important point is that Ciferri, despite his extensive study of this genus and his erection of several new species on composites in North America (4), apparently failed to observe abundant morphological differences existing among certain of the groups involved. *Entyloma Calendulae* and *E. Compositarum* are almost as dissimilar as any two species of the genus.

In adapting this modified morphological species concept to the group under discussion, no one is more aware than the writer that it is imperfect and that certain arbitrary decisions have to be made. These difficulties have considerably delayed completion of the study. Clearly one cannot rely solely on morphology. For example, *Entyloma Lobeliae*, recently collected locally, was suspected of being *E. Compositarum* until the host developed sufficiently to be recognized as *Lobelia inflata*; yet probably no one would suggest that these species should be united, although it is conceivable that their similar morphology is ascribable to a common origin rather than to chance convergence.

Morphological constancy, sufficient to prevent the masking of small differences between species, is a prerequisite to such a system. Studies in some genera of the Hyphomycetes suggest that variation is so great in many species as to make any approach to a purely morphological classification hopeless. Even this conclusion does not make careful measurement of specimens unnecessary; without it one cannot hope to say how many species actually attack a plant. One must, however, rely rather largely on host relationships for the delimitation of species. Ideally every fungus would be cultured and its host range determined by experiment, but in practice such a

treatment can only be applied to a trifling proportion of our specimens, and one must, in any event, make use of herbarium material that was not subjected to experiment.

In the leaf smuts under consideration it has not been possible to examine adequate material on some hosts; but, where abundant specimens have been available, variability has proved to be so slight that some confidence may be placed in an adequate description.

In considering such a climax group as the Compositae one should recollect that physiological differentiation need not always exactly follow morphological trends. Accordingly the limits of tribes and genera are sometimes indefinite, and parasitic fungi may have a seemingly anomalous host range. Two beliefs concerning the Compositae have to some extent influenced the assignment of specific limits in this study: firstly, that the various tribes of the Tubuliflorae are much more intimately related to each other than to the Liguliflorae; and, secondly, that the segregation of the "Ambrosiaceae" from the Tubuliflorae is not justified. These beliefs stem in part from the relationship of these plants with the fungi that parasitize them.

The characters that have proved most useful in drawing up practical descriptions of these fungi are: minimum and maximum length of teliospores, minimum and maximum width of teliospores, minimum and maximum teliospore wall thickness, density of teliospore distribution, and presence or absence of conidia or conidiophores. The literature abounds with descriptions of spores such as "mostly 12–15μ diameter" and "averaging 14μ long". In practice, average widths and lengths are very difficult to determine accurately. If the spores were dispersed upon a slide, complete fields could be measured and the danger of unconscious selection would be reduced to a minimum; but in a section there is always a considerable proportion of spores that cannot be clearly viewed, and selection, with its threat of error, is inevitable. If, after measuring a number of randomly selected spores, one searches for extremes of length and width, it will generally be found, after examining two or three sections, that little further enlargement of the range can be secured; and the extremes so found usually agree quite closely with those of other specimens. The maximum length tends to be more variable than other dimensions, owing to the occasional occurrence of distorted elongate spores. Measurement of these spores with relatively constant but small differences should always be made under the oil-immersion objective. Spore wall thickness must be used with discretion. Slight differences tend to occur from host to host, and the walls are generally thicker in *Entyloma polysporum* than in *E. Compositarum*; but the range in a given specimen is generally too great to merit much faith in wall thickness alone, except in outstanding forms such as the fungus on *Rudbeckia hirta*. The approximate wall thicknesses given in many descriptions have no practical value. The density of teliospore distribution has proved to be more constant than might be expected, both in a given host and from one host to another. Conidia may be difficult to find, especially in old specimens, but conidiophores can almost always be found in the stomata in

species that are known to bear conidia; occasionally it is impossible to find conidiophores in old lesions overrun by saprophytic fungi.

Sections are required for adequate examination, but the making of them need not be as tedious as cutting sections in pith demands. Many hours have been saved by the development of a technique of chopping sections under the dissecting microscope (Savile, 16). This method has the further advantage of being economical of material, an important factor in the examination of rare and scanty specimens.

The dimensions of the conidia have not proved to be of much value; for it is often impossible to find enough in a specimen to determine the size range; variability seems to be as great within as between species, and those in a particular specimen may be acicular or falcate according to the weather conditions prior to the time of collection.

One of the characters listed may be atypical in a given specimen, but most collections conform to a particular concept well enough to allow one to assign them fairly confidently to a species.

The appearance of the lesions is generally fairly constant on a given plant, but it may vary widely from host to host. On certain plants that are attacked by more than one species of *Entyloma* it has diagnostic value.

In Table I will be found the characteristics of a large number of North American collections of *Entyloma* spp. on Compositae and of some specimens from other parts of the world. The European material available has not been sufficient to decide the relationships of certain European and American species, but it serves to indicate the problems involved and the need for critical study of specimens on hand. In the table the specimens are grouped, by hosts, in two categories: first, those assignable to *E. polysporum* or closely related species; and, second, those belonging to *E. Compositarum* or other conidium-bearing species. This arrangement has been adopted in order to emphasize the distinctness of the two phyletic lines involved. The last column in the table gives the preferred name for each specimen; but several of these assignments are open to some doubt, and they should not be accepted without reference to the text where all questionable identifications are discussed under the appropriate host.

Most North American collections fall into one or other of the two well-defined species, *Entyloma Compositarum* Farl. and *E. polysporum* (Pk.) Farl., but there are, on certain hosts, fungi in which some morphological differentiation appears to be constant. As Zundel (21) has noted, *E. polysporum* is very similar to the European species, *E. Calendulae* (Oud.) de Bary, and may have to be included with it. It is kept distinct for the present, but insufficient European material on *Calendula* has been seen to satisfy the writer as to whether the small differences that seem to exist are real and constant. As noted below under *Calendula* and *Erigeron*, the concept of *E. Calendulae* has become seriously confused.

TABLE I

A COMPARISON OF ENTYLOMAS ON VARIOUS COMPOSITAE, GROUPED ACCORDING TO TYPE

Specimen[1], name under which issued, and locality			Host	Teliospore dimensions (μ)			Spore distribution[2]	Conidia[3]	Preferred name[4]
				Length	Width	Wall			
F. Col. 541	*E. Compositarum*	N.Y.	*Ambrosia elatior*	10.3–18.0	9.3–14.0	1.0–3.0	4	–	*E. polysporum*
S. & E. Ec. F. 292*a*	"	Mich.	" "	9.5–21.5	9.0–15.0	1.0–3.5	4	–	"
S. & E. Ec. F. 292*b*	"	Ill.	" "	10.0–15.0	8.5–12.8	1.0–3.0	4	–	"
DAOM 15354	*E. polysporum*	Ont.	" "	8.8–17.5	8.3–14.0	0.8–2.8	4	–	"
DAOM 15445	"	Ont.	" "	9.8–18.3	8.5–15.0	1.0–2.5	4	–	"
Roum. F. Sel. 4868	"	N.Y.	" *trifida*	10.5–18.3	9.3–13.5	1.0–2.5	4	–	"
DAOM 15669 (ex *G.L.Z.*)	*E.* sp.	Pa.	" "	(8.5)10.0–17.0	8.5–13.5	0.8–3.2	4	–	"
DAOM 15670 (ex *G.L.Z.*)	"	Pa.	" "	9.2–17.5	8.5–14.5	0.8–2.5	4	–	"
DAOM 15671 (ex *G.L.Z.*)	"	Pa.	" "	9.5–17.8	8.5–13.0	1.0–2.5	4	–	"
TRT 6301	*E. Compositarum*	Ont.	*Aster macrophyllus*	10.0–16.5	9.0–13.3	1.0–3.0	4	–	"
TRT	"	Ont.	" "	9.2–16.5	8.5–14.0	0.7–2.5	4	–	"
TRT (ex U. of Wis.)	"	Wis.	" "	9.0–14.0	7.8–14.0	0.7–2.5	4	–	"
H.C.G. 388	*E. Aster-sericeanum*	Wis.	" *sericeus*	11.0–19.5	10.0–18.0	1.0–2.5(2.8)	4	–	"
H.C.G. 890	" "	Wis.	" "	10.2–18.5	9.8–16.0	0.8–2.2	4	–	"
H.C.G. 891	" "	Wis.	" "	10.5–16.5	9.4–14.5	0.8–2.0	4	–	"
DAOM 1012	*E. Calendulae*	Holland	*Calendula officinalis*	8.7–17.5	7.3–14.0	0.5–2.0(2.5)	2	–	*E. Calendulae*
D. Sacc. Myc. It. 893	"	Sardinia	" "	8.5–15.5	7.5–12.0	0.5–2.5	3	–	"
Roum. F. Sel. 3119	"	Belgium	" "	7.0–14.5(16.5)	7.0–13.0	0.2–1.5(1.8)	2	–	"
D. Sacc. Myc. It. 720	"	Sicily	*Chrysanthemum coronarium*	9.8–17.0	8.7–14.5	1.0–2.8	4	–	*E. polysporum*
TRT (leg. A. Ludwig)	*E. Ludwigianum*	Germany	" *segetum*	9.5–15.7	7.8–12.5	0.5–2.0	3	–	"
TRT	*E. Dahliae*	Moravia	*Dahlia pinnata*	9.5–18.5	8.3–14.0	0.7–2.8	4	–	*E. Dahliae*
G.L.Z. (ex R. P. White)	"	N.J.	" "	9.5–17.5	8.2–14.2	0.5–2.8	2	–	"
TRT (ex Cornell 20887)	"	N.Y.	" "	9.5–18.0	8.0–14.0	0.7–2.5(4.2)	2	–	"
F. Col. 1875	(*Septoria Lepachidis*)	Kans.	*Lepachys columnaris*	10.0–25.5	9.0–22.0	1.0–5.5	4	–	Doubtful
F. Col. 3424	*E. polysporum*	Ont.	*Rudbeckia hirta*	10.5–18.0	10.0–17.0	1.0–5.0	4	–	*E. Davisii*
Sydow Ust. 466 (*H.S.J.*)	"	Ont.	" "	9.2–18.8	8.8–14.2	0.5–5.0	4	–	"
TRT (ex U. of Wis.)	"	Wis.	" "	12.5–21.2	10.5–16.5	1.5–7.5	4	–	"
Sydow Ust. 488 (*TRT*)	*E. Matricariae*	Denmark	*Achillea millefolium*	9.5–13.0	7.5–12.0	0.3–1.2	1–2	–	*E. Compositarum*
DAOM 14627	*E. Achilleae*	Man.	" "	11.2–14.8	9.5–12.0	0.6–1.2	1	A	"
F. Col. 3223	*E. Compositarum*	Md.	*Ambrosia trifida*	8.0–11.2	7.2– 9.8	0.3–0.7	2	A	"
F. Col. 3319	"	Ont.	" "	8.0–13.0	7.5–10.5	0.5–1.5	2	H	"
S. & E. Ec. F. 294*b*	"	N.D.	" "	7.8–14.0	7.2–11.4	0.4–0.7	2	H	"
DAOM 14628	"	Man.	" "	9.8–14.0	7.8–10.6	0.5–1.2	2	H	"

TABLE I—*Continued*

A COMPARISON OF ENTYLOMAS ON VARIOUS COMPOSITAE, GROUPED ACCORDING TO TYPE—*Continued*

Specimen[1], name under which issued, and locality			Host	Teliospore dimensions (μ)			Spore distribution[2]	Conidia[3]	Preferred name[4]
				Length	Width	Wall			
F. Col. 540	*E. arnicale*	Wash.	*Arnica Chamissonis*	9.5–15.5	8.5–14.0	1.0–3.0	2	H	*E. arnicale*
DAOM 6750	"	B.C.	" *cordifolia*	10.5–17.0	8.5–15.0	0.5–3.0	2	H	"
DAOM 7787	"	B.C.	" "	10.0–14.5	8.5–14.5	0.7–3.5	2	H	"
DAOM 7788	"	B.C.	" "	10.0–15.7	9.2–14.5	0.7–3.5	2	H	"
F. Col. 2368	*Ramularia arnicalis*	Utah	" *mollis*	9.8–14.8	9.0–12.0	0.7–2.5	2	H	"
H.S.J. (leg. P. Unamono)	*E. Calendulae*	Spain	" *montana*	8.5–14.5	7.0–13.8	0.2–1.5	2	–	*E. Compositarum*
H.S.J. (leg. P. Cruchet)	"	Switzerland	" "	8.3–13.5	7.4–12.2	0.3–1.2	2	A	"
Sydow Ust. 322 (*TRT*)	*E. Arnicae*	Germany	" "	8.0–14.2	7.3–12.0	0.2–1.0	2	A	"
F. Col. 5014	*E. Compositarum*	Wyo.	*Aster adscendens*	8.2–13.0	8.0–10.5	0.5–1.5	2	A	"
DAOM 14629	"	Man.	" *laevis*	8.2–13.5	8.0–13.0	0.5–1.5	2	A	"
H.S.J. (leg. Neger)	"	Chile	" *Vahlii*	8.0–13.5	7.2–12.5	0.2–1.5	2	A	"
H.S.J. (leg. P. Cruchet)	*E. Bellidiastri*	Switzerland	*Bellidiastrum Michelii*	8.5–14.2	7.5–11.3	0.5–1.5	2	A	"
H.S.J. (l. D. & P. Cruchet)	*E. Bellidis*	Switzerland	*Bellis perennis*	8.7–13.0	7.0–11.5	0.3–0.7	2	A	"
S. & E. E. F. C107 (*H.S.J.*)	*E. guaraniticum*	Puerto Rico	*Bidens leucantha*	8.2–14.5(15.5)	6.5–11.3	0.2–0.5(0.8)	2	H	"
E. West	"	Fla.	" *pilosa*	9.8–18.3	8.5–15.0	1.0–2.5(2.8)	4	A	*E. guaraniticum*
TRT (ex Cornell 15903)	*E. Calendulae*	N.Y.	*Calendula officinalis*	8.0–14.0(15.5)	7.5–12.5	0.2–2.2	2	A	*E. Compositarum*
Roum. F. Sel. 4869	*E. Matricariae* f. *Chrysanthemi*	Switzerland	*Chrysanthemum alpinum*	7.5–15.0	7.2–12.2	0.2–1.0	2	A	"
DAOM 8056	*E. Compositarum*	Sask.	*Chrysopsis hirsutissima*	8.5–13.5	7.0–11.5	0.4–0.9	2	A	"
DAOM 14646	"	Sask.	" *villosa*	8.5–14.0	7.3–12.0	0.3–0.7	2	A	"
S. & E. E. F. C108(*H.S.J.*)	*E. Holwayi*	Mexico	*Cosmos sulphureus*	8.5–14.2(15.7)	6.8–13.0	0.7–2.0(2.5)	2	H	*E. Holwayi*
DAOM 14459	*E. Compositarum*	Ont.	*Erigeron annuus*	7.7–14.5	7.0–12.8	0.8–2.7	2	A	*E. Compositarum*
S. & E. E. F. C17 (*H.S.J.*)	"	Ore.	*Eupatorium ageratoides*	7.5–13.5	6.8–11.5	0.2–1.2	1	A	"
DAGM 6867	*E. polysporum*	Sask.	*Gaillardia aristata*	8.0–14.0	7.0–12.8	0.3–1.7	2	A	"
DAOM 14365	"	Man.	" "	8.5–12.5	7.5–10.3	0.5–1.7	2	A	"
DAOM 14367	"	Man.	" "	8.5–13.0	7.0–11.3	0.5–1.4	2	A	"
DAOM 14368	"	Man.	" "	8.0–12.5	7.0–10.7	0.7–1.7	2	A	"
DAOM 13837	*E. Compositarum*	Ont.	" "	8.5–13.5	7.2–11.0	0.5–1.6	2	A	"
DAOM 14464	"	Ont.	" "	8.0–12.5	7.3–11.0	0.5–1.4	2	A	"
F. Col. 4820	*E. polysporum*	Neb.	" *pulchella*	8.5–14.0	7.5–13.0	0.7–2.0	2	A	"
F. Col. 4917	"	Mont.	*Helenium autumnale*	8.5–14.0	7.3–10.5	1.0–1.7	2	A	"
DAOM 7701	"	Sask.	" *montanum*	8.2–14.0	7.2–11.5	0.4–1.5	2	A	"
DAOM (leg. E.Bartholemew)	*E. Compositarum*	Kans.	*Heterotheca subaxillaris*	9.2–12.8	7.2–11.5	0.4–1.5	2	A	"

TABLE I—*Concluded*

A COMPARISON OF ENTYLOMAS ON VARIOUS COMPOSITAE, GROUPED ACCORDING TO TYPE—*Concluded*

Specimen[1], name under which issued, and locality			Host	Teliospore dimensions (μ)			Spore distribution[2]	Conidia[3]	Preferred name[4]
				Length	Width	Wall			
F. Dak. 661 (*TRT*)	*E. Compositarium*	S.D.	*Lepachys columnaris*	8.5–15.5	7.8–14.5	0.7–2.2	2	–	Doubtful
S. & E. Ec. F. C18 (*H.S.J.*)	"	Ill.	" *pinnata*	8.5–13.2	7.5–11.0	0.2–0.7	2	A	*E. Compositarum*
H.C.G. 883	"	Wis.	" "	8.5–13.5	7.3–10.5	0.3–1.2	2	A	"
U. of Mich. (ex U. of Wis.)	"	Wis.	" "	8.0–14.0	7.3–10.0	0.2–0.7	2	A	"
U. of Mich.	"	Mich.	" "	9.2–12.5	7.0–10.0	0.2–0.7	2	A	"
Fl. of Ore. 1826 (*H.S.J.*)	"	Ore.	*Madia* sp.	8.5–12.5	6.8–11.0	0.5–1.4	1	–	"
DAOM (leg. C. J. Johanson)	*E. Matricariae*	Sweden	*Matricaria inodora*	10.5–16.5	9.2–15.2	0.3–1.5(1.8)	2	A	*E. Matricariae*
Fl. Hung. Exs. 602	"	Hungary	" "	9.7–17.0	9.0–14.5	0.5–1.5	2	A	"
TRT (ex U. of Wis.)	*E. Compositarum*	Wis.	*Rudbeckia laciniata*	9.2–15.5	7.8–14.0	0.5–2.2	2	H	*E. Compositarum*
H.S.J.	"	Ind.	*Senecio aureus*	8.3–14.5	7.8–13.0	0.5–1.4	2	A	"

[1] *Abbreviations for specimens, excluding standard exsiccati. DAOM = Mycological Herbarium, Dominion Dept. of Agriculture, Ottawa, Canada. TRT = Univ. of Toronto. U. of Mich. = Univ. of Michigan. U. of Wis. = Univ. of Wisconsin. G.L.Z. = Dr. G. L. Zundel, Pennsylvania State College. H.C.G. = Dr. H. C. Greene, Univ. of Wisconsin. H.S.J. = Prof. H. S. Jackson, Univ. of Toronto.*

[2] *Under spore distribution, 1 = sparse, 2 = abundant, 3 = crowded, 4 = densely packed.*

[3] *Under conidia, – = lacking, A = amphigenous, H = hypophyllous.*

[4] *Some assignments are open to question; the names given in this column should not be accepted without reference to the text under the appropriate host genus.*

Emended descriptions of *E. polysporum* and *E. Compositarum* are presented herewith. Information that is readily available in the *North American Flora* is omitted. Information concerning emended exsiccati names will be found below in the text and in Table I.

Entyloma polysporum (Pk.) Farl. Teliospores 9.0–17.0 (21.5) × 8.5–13.5 (16)μ, densely crowded, displacing most chlorenchyma tissue, wall usually 1.0–3.0μ; conidia and conidiophores completely lacking (Figs. 2, 6).

Entyloma Compositarum Farl. Teliospores (7.5) 8.0–13.0 (15.5) × (6.8) 7.2–11.5 (14.0)μ, generally abundant, but not densely crowded or displacing chlorenchyma tissue, wall (0.2) 0.7–1.5 (2.7)μ; conidia generally evident, either falcate 7.0–25.0 × 2.0–3.5 (5.0)μ, or acicular 26.0–46.0 × 1.0–1.5μ; conidiophores almost always densely crowded in stomata, amphigenous or hypophyllous according to host (Figs. 1, 3, 4, 5).

To avoid undue repetition in dealing with specimens of doubtful identity, all material examined will be discussed under the appropriate host genera. Ciferri species mentioned are described in his 1928 paper unless the contrary is indicated.

Achillea millefolium.—*DAOM* 14627 is part of the collection mentioned by Zundel (21) and Bisby *et al.* (2), and is apparently the only record of an *Entyloma* on this host in North America. This specimen and Sydow Ustilagineen 488 are doubtfully distinct from *E. Compositarum*. The Manitoba specimen shows very abundant conidia, but the teliospores are so sparse that the dimensions given probably do not represent the whole range. The lack of conidiophores in the Sydow specimen may be due to the material being old and invaded by saprophytes. *E. Achilleae* Magnus was briefly described as having spores 12.5 × 10.5μ and no authentic material has been seen. Liro (10) describes this species as having spores 19–18 (9–18 intended?) × 8–13μ, and it is possible that two species are involved.

Ambrosia.—In addition to the distinctions indicated in the table, *E. polysporum* produces moderately large, round lesions that may be pale, dark green or necrotic, whereas *E. Compositarum* forms small, angular lesions that usually bear masses of conidia on the under surface and may have some above. The issuing of three exsiccati of *E. polysporum* as *E. Compositarum* has doubtless caused much confusion. Fungi Columb. 541 was corrected by Clinton (7), the error of Seym. and Earle Econ. Fungi 292*a* was pointed out by Savile (13), and Seym. and Earle Econ. Fungi 292*b* is here corrected for the first time (cf. Figs. 1, 2, 5, 6). It may further be noted that this institution's copy of

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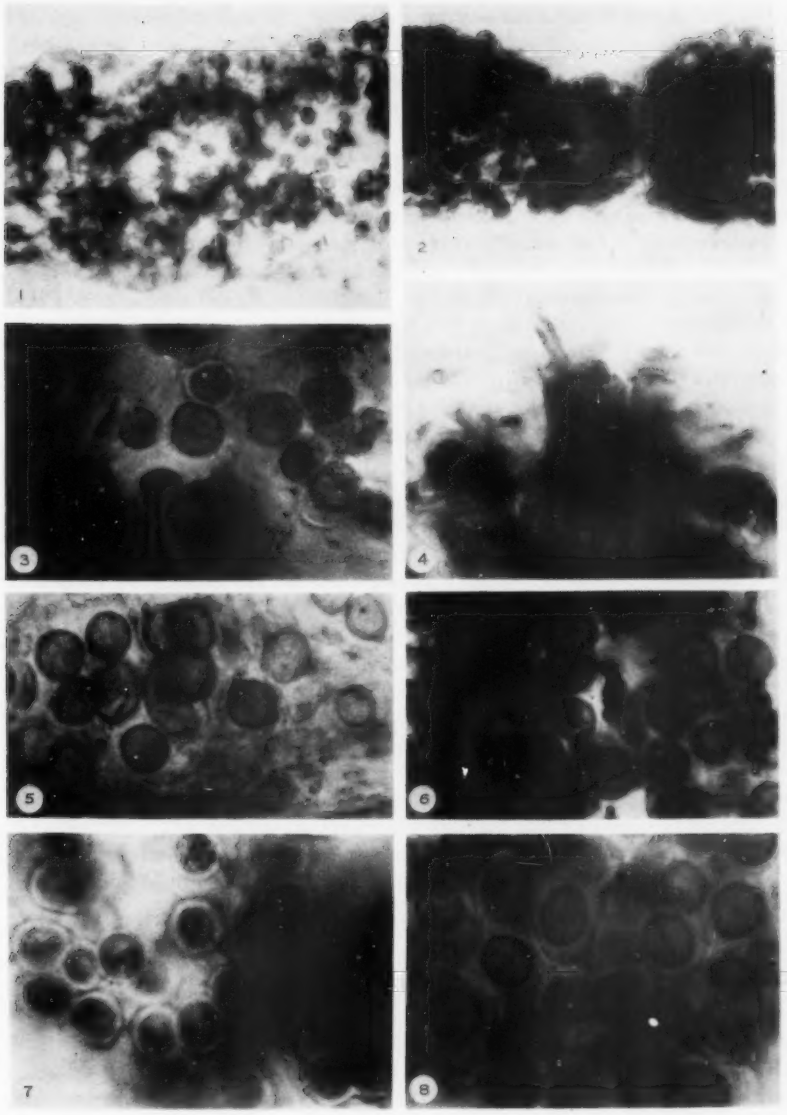
FIGS. 1 TO 8. *Photomicrographs of* Entyloma *spp., from freehand sections in lactophenol with a trace of cotton blue.* FIGS. 1 to 2, ×*92; remainder,* ×*800.* FIG. 1. E. Compositarum *in leaf of* Ambrosia elatior; *spores numerous but not crowded.* FIG. 2. E. polysporum *in leaf of* A. elatior; *spores densely crowded.* FIG. 3. *Spores of* E. Compositarum *in* Gaillardia aristata. FIG. 4. *Conidiophores of* E. Compositarum *massed in stoma of* G. aristata. FIG. 5. *Spores of* E. Compositarum *in* Ambrosia trifida. FIG. 6. *Spores of* E. polysporum *in* A. elatior. FIG. 7. *Spores of* E. polysporum *in* Aster macrophyllus. FIG. 8. *Spores of* E. Davisii *in* Rudbeckia hirta.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Seym. and Earle Econ. Fungi 294*b* contains a species of *Stagonospora* associated with the *Entyloma*. This fungus, which has been described elsewhere (Savile, 15), is of interest because of a similar association to be mentioned below under *Lepachys*.

Arnica.—The European specimens on *A. montana* are all assignable to *E. Compositarum*. The lesions are small and round. The first specimen listed, though collected in May, was overrun by saprophytes and it is impossible to say whether or not it had possessed conidiophores; it may consist of overwintered basal leaves. The North American collections are all *E. arnicale* E. and E., which is evidently an offshoot of *E. Compositarum* distinguished by slightly larger spores, frequently ornamented with conspicuous curving bands of semicircular cross section. The lesions are moderately large and round. This fungus is definitely not of the 'polysporum' phyletic line. *E. arnicale* is also reported on *A. fulgens* and *A. latifolia*, and it may be noted that the hosts are distributed among the three subgenera of *Arnica* that occur in the area of distribution of the smut, namely British Columbia, Washington, Idaho, Montana, Wyoming, Utah, and Colorado; indeed this area is the distribution centre of the genus *Arnica*, as is clearly shown by Maguire (11).

Aster.—*E. Compositarum* was described from *A. puniceus* and probably attacks a considerable number of species of *Aster*. The specimen on *A. Vahlii* from Chile shows moderately large, round lesions, but on *A. adscendens* and *A. laevis* the spots are small and angular. The fungus on *A. sericeus*, recently described by Zundel (22) as *E. Aster-sericeanum*, is indistinguishable from *E. polysporum* to which it is here assigned. On *A. sericeus* the lesions are small and variable in shape. The smut on *Aster macrophyllus* is also assigned to *E. polysporum*. If all collections on this host showed the size range of the Wisconsin specimen it might be treated as a distinct species; but the ranges shown by the Ontario specimens are normal for *E. polysporum*, although there is perhaps a preponderance of small spores. The densely packed spores and the complete lack of conidiophores in three abundant collections, all in prime condition, exclude the possibility of this fungus being *E. Compositarum* (cf. Fig. 7). The lesions are strikingly angular and narrowly elongate. In addition to the specimens listed, two in the University of Toronto Herbarium, on *Aster* sp. from Colorado, are typical *E. Compositarum*.

Bellidiastrum.—This specimen is typical *E. Compositarum*. The lesions are small and generally round.

Bellis.—The specimen is typical *E. Compositarum*. The lesions are small, round, and inconspicuous.

Bidens.—Seym. and Earle Econ. Fungi *C*107 is here assigned to *E. Compositarum*; the maximum spore length is somewhat large, but in other respects the fungus is typical of this species. It is possible that *E. incertum*, published by Ciferri without description but stated to have smaller spores than *E. guaraniticum* Speg., belongs here. The specimen on *B. pilosa*, sent from Florida by Mr. Erdman West, is taken to be the true *E. guaraniticum*. It is unusual in

that it possesses large, densely crowded teliospores, but produces conidia. It is perhaps more closely allied to some South American complex than to either of the main North American phyletic lines. Clinton (7) describes the spores as 11–20μ long and more or less adherent in masses or rows. Saccardo (12), in what is presumably an exact translation of the original description, says: "sporis in cellulis parenchymaticis constipatis, globosis sed e mutua pressione saepius irregulariter angulosis, 10–14μ diam., crassiuscule tunicatis". This description leaves the full range of spore dimensions in doubt, but in other respects it fits the Florida specimen well except for the failure to mention conidia. However, conidia have so often been overlooked that their absence cannot be assumed unless the author explicitly mentions that they could not be found. Of course, the spores are not actually crowded in the cells; they form intercellularly and their growth causes the collapse and partial disappearance of the parenchyma tissue. The lesions are round in both specimens seen, but are much larger in the Florida specimen than the other. *E. Spegazzinii* Sacc. and Syd. (*E. Bidentis* Speg.) is stated to have even larger spores than *E. guaraniticum*. *E. Bidentis* P. Henn., from Africa, described as having spores 10–15 × 9–14μ with walls 1–1.5μ, might be *E. Compositarum*.

Calendula.—The three European specimens examined are presumably typical *E. Calendulae*. The measurements indicate that the spores are slightly smaller than those of *E. polysporum*, particularly as to minimum length and width, and that they are less crowded in the leaf. These are admittedly small differences and adequate study of European material may eventually necessitate *E. polysporum* being treated as a synonym of *E. Calendulae*, as Zundel (21) has suggested. The evaluation of some of the European forms without conidia has proved to be the most difficult part of this study. The New York specimen on *Calendula* is best regarded as *E. Compositarum* although the upper limit of spore length is somewhat high and the spore dimensions agree rather closely with those of the European specimens. It has abundant conidia, whereas all available descriptions and specimens indicate that conidia are never produced on *Calendula* in Europe. The lesions are round in all specimens and vary considerably in size. Unfortunately the concept of *E. Calendulae* has been seriously confused through smuts on various composites being assigned to it with little consideration as to whether or not they were morphologically similar. Later the Sydows (19) broke up the collective species into eight "biological species" without any descriptions, thereby creating seven *nomina nuda*. In so doing they stated that all were morphologically indistinguishable, yet the segregate on *Erigeron* bears conidia and is probably *E. Compositarum*.

Chrysanthemum and Related Genera.—There seem to be no records of these plants being attacked in North America, but several species of *Entyloma* have been described from *Chrysanthemum* and *Matricaria* in Europe. *E. Matricariae* Rostr. appears to be a valid species; it somewhat resembles *E. Compositarum* but has decidedly larger spores. The Johanson specimen in the Division Herbarium may be part of the type, which was issued in

Thuemen Mycotheca Universalis 2223. The label of the latter agrees with that on the specimen examined except that the date is given as Sept. 1883, whereas ours is marked 18 Sept. 1883. The specimen can certainly be considered as authentic and makes possible a more adequate description. Conidiophores are plentiful but no conidia were seen. The measurements for Flora Hungarica Exsiccata 602 are combined from the packet in this Division and the one in the University of Toronto; a few conidia were seen and all were about 16 × 2.5μ as opposed to 4–6 × 2–2.5μ given by Rostrup, a further indication of the variability of conidia. Roumeguere's *E. Matricariae* f. *Chrysanthemi* appears to be *E. Compositarum*. *E. Lagerheimi* Ciferri (*E. Matricariae* Lagerheim) has not been examined; but it is described (Ciferri, 3) as having spores 20–24 × 16–18μ, rarely 28μ diam., and is evidently distinct. Ciferri states in the same paper that *E. Chrysanthemi* Syd., with much larger spores, is *Protomycopsis leucanthemi* Magn. *E. Ludwigianum* was described by Sydow (18) as having spores 10–13 × 9–11.5μ. The specimen listed is from the type host and locality and was collected about a month later than the type. It is presumably authentic. As the table shows it is close to *E. polysporum* and may not be distinct. It has small to moderately large, round lesions. D. Sacc. Myc. Ital. 720 on *Chrysanthemum coronarium* (*Pinardia c.*), issued as *E. Calendulae*, is indistinguishable from *E. polysporum*. It produces large, diffuse lesions. This is Ciferri's *E. Scalianum*. Sydow seems to have segregated *E. Ludwigianum* from it mainly because his fungus was collected in Germany and the other in Sicily. The final disposition of these fungi in relation to *E. Calendulae* and *E. polysporum* must await the examination of considerably more material.

Chrysopsis.—The two specimens listed, and another from Saskatchewan on *C. hirsutissima*, are typical *E. Compositarum*. The lesions are moderately large and round.

Cosmos.—The specimen seen is one of the two exsiccati specimens listed. The type, P. Sydow Ust. 282 from the same locailty, has not been examined. The lesions are moderately large and round. Clinton (6, 7) considered this fungus, *E. Holwayi* Syd., to be doubtfully distinct from *E. polysporum*, but in this specimen there are abundant hypophyllous conidiophores. It differs from *E. Compositarum* only in having a few abnormally long spores (Clinton describes them as up to 17μ long) with rather thick walls; further specimens are needed to show whether these long spores occur regularly. In the meantime it maybe kept distinct.

Dahlia.—The three specimens seen all have large, more or less round lesions, and agree very closely except that in the two American collections the teliospores are numerous, whereas in the European fungus they are packed almost as closely as in *E. polysporum*. This is a part of the 'Calendulae-polysporum' complex and may as well be left as *E. Dahliae* Syd. until the whole group is better understood.

Erigeron.—A number of North American collections have been made on *Erigeron* spp., especially from the far western United States, and all have

been assigned to *Entyloma Compositarum*. The specimen listed was collected near Ottawa before the large circular lesions had become necrotic, and was assumed to be *Cercosporella cana*, which is fairly common locally. It was not studied until some months later; and it has not been rediscovered despite an intensive search. Because no collections on *Erigeron* seem to have been made within some hundreds of miles of Ottawa, it was thought possible that infection might have taken place from nearby *Gaillardia*. A small scale attempt to infect *Erigeron annuus* in 1945 failed, but was inconclusive because hardly any spread occurred even on *Gaillardia*. There seems to be no justification for excluding this fungus from *E. Compositarum*. The identification and naming of the smuts on *Erigeron* have been complicated by the Sydows' (19) treatment of the fungi that had passed as *Entyloma Calendulae*. *Entyloma Erigerontis* Syd. was based upon the fungus on *Erigeron elongatus* (= *E. acris?*) in Norway, and, together with the other undescribed segregates, was stated to be morphologically indistinguishable from *Entyloma Calendulae*. In Ciferri's description of *Entyloma Erigerontis* from Vestergren's Microm. Rar. Sel. 325, which the Sydows apparently had before them when they named the species, the spores are stated to be roundish, 10–15μ diam., rarely to 17μ, commonly 10–12μ, wall 1.0–1.5μ, smooth, and conidia are not mentioned; yet Liro (10) describes the fungus as having conidia, and in fact his description fits *Entyloma Compositarum*. The lack of agreement suggests that there might be two species on *Erigeron* in northern Europe. *Entyloma Fischeri* Thuem. was described from Austria on *Stenactis bellidiflora* A. Br. *Stenactis* is a segregate of *Erigeron* and, according to Hegi (9), *S. bellidiflora* is identical with *Erigeron annuus* (L.) Pers., which is well established in parts of Europe. Winter (20) describes *Entyloma Fischeri* as having spores sparse, broadly ellipsoid, translucent yellowish, 14–18 × 12–14μ, wall smooth, seemingly thin. Saccardo (12) gives the last figure as 18μ, but this is apparently a misprint. The Division material of Roum. Fungi Sel. 4728 on *Stenactis annua* (*Erigeron annuus*) is sterile. This fungus is evidently distinct from *Entyloma Compositarum*. From the published description it is impossible to tell whether it is distinct either from Ciferri's concept of *Entyloma Erigerontis*, or from *Entyloma occultum* Ciferri on *Erigeron spathulatus*, Dominican Republic, with spores 11–21μ diam.

Eupatorium.—The specimen listed is typical *Entyloma Compositarum*. Neither this specimen nor Ciferri's description support the validity of *Entyloma Eupatorii*.

Gaillardia.—It is plain that the fungus on *G. aristata* from Saskatchewan, Manitoba, and eastern Ontario, and on *G. pulchella* from Nebraska, is *E. Compositarum* (cf. Figs. 3 and 4). In view of the findings in other host genera, it is possible that *E. polysporum* does occur on *Gaillardia*, but probably most such reports result directly or indirectly from Fungi Columb. 4820 being issued as *E. polysporum*. Several additional collections from Manitoba and Ontario that add nothing to the dimensions shown in the table have been omitted. The lesions on *Gaillardia* are moderate to large and round. The herbarium

of the Dominion Laboratory of Plant Pathology, Winnipeg, Man., contains no material specifically representing Hanna's (8) demonstration of the formation of conidia in culture by what was thought to be *E. polysporum* from *G. aristata*; but from the evidence presented here it is almost certain that he was dealing with *E. Compositarum*, and the production of conidia was therefore to be expected. *E. Gaillardiae* Speg. (17) has much larger spores and is clearly distinct, if it is actually an *Entyloma*.

Helenium.—Both specimens are typical *E. Compositarum* and have large, round lesions. The misnaming of Fungi Columb. 4917 has already been noted (Savile, 13).

Heterotheca.—This specimen in the Division Herbarium was collected by E. Bartholemew, Rooks Co., Kansas, 21 Aug. 1895. It was issued, without number, under a Kansas Fungi label, and is *E. Compositarum* as marked. It has small, angular lesions.

Lepachys.—The specimens on *L. pinnata* are typical *E. Compositarum*; there is no morphological support for Ciferri's segregation of this fungus as *E. Lepachydis*. It forms small, angular lesions. The identities of the fungi on *L. columnaris* are subject to some doubt. Fungi Dak. 661 has spores slightly larger than is usual for *E. Compositarum*, which probably accounts for Zundel (21) having transferred it to *E. polysporum*; and the walls show some tendency to be banded like those of *E. arnicale*. The spore distribution is as for *E. Compositarum*, but no conidiophores could be found. Conceivably conidiophores might occasionally be lacking from a specimen in good condition in a species where they generally occur; a few specimens have, indeed, been seen in which they were scarce. This specimen is not believed to be *E. polysporum*, but until further specimens have been seen no definite assignments should be made. It forms large, round lesions. When Prof. H. S. Jackson sent this specimen to the writer for examination he noted that another fungus appeared to be present. Examination showed pycnidia of a *Septoria* to be abundant on many of the *Entyloma* lesions and to occur occasionally elsewhere on the leaf. In identifying the *Septoria* as *S. Lepachydis* Fungi Columb. 1875 was examined. This material bore a similar *Septoria*, but it could be seen at a glance that an *Entyloma* was again associated with it. Sections showed that this was yet another fungus. It is of the 'polysporum' type, but, like *E. Davisii* on *Rudbeckia hirta*, the spores have extremely thick walls; it is probably a distinct species, but further material is needed to assess its full range of variation; its lesions are large and round. The *Septoria* seems to be a weak parasite that readily invades tissue attacked by these smuts. Mycologists interested in this complex may find it profitable to examine their specimens of *S. Lepachydis*. The association is evidently similar to that of a *Stagonospora* with *E. Compositarum*, mentioned under *Ambrosia*.

Madia.—Although the specimen was collected in the spring (10 May 1914), the leaves were largely dead and are overgrown by saprophytes, which suggests that they had overwintered. Under the circumstances the lack of conidiophores is not surprising and the material may well be left in *E. Compositarum*.

The lesions are small and round. Unless more normal material should reveal distinctions there can be no reason for adopting Ciferri's name *E. Madiae.*

Matricaria.—See under *Chrysanthemum.*

Rudbeckia.—The three specimens on *R. hirta*, all issued as *E. polysporum*, are of the same type as that species, but the spores consistently have such remarkably thick walls (Fig. 8) that the adoption of Ciferri's name *E. Davisii* is fully justified. The lesions are generally large and angular. The fungus on *E. laciniata*, segregated by Ciferri as *E. anceps*, is *E. Compositarum*; it forms small, angular lesions.

Senecio.—The specimen seen is unquestionably *E. Compositarum.* The type of *E. wisconsiniense* Ciferri has not been seen, but the description does not suggest that it is different. The positions of *E. Saccardianum* Scalia and of *E. bavaricum* Syd., which may be identical with it, are doubtful; they may be close to *E. Calendulae.*

It is impossible, without a great deal more material from other parts of the world, to draw definite conclusions about the geographic origins of the morphological types under discussion. The widespread distribution of *E. Compositarum* in North America and the occurrence of *E. arnicale*, a well-marked segregate, in the Rocky Mountains region, suggest that this group originated here and has spread into South America and Europe. Much spread to Europe may have occurred during the last two hundred years along with weed hosts. The comparative restriction of *E. polysporum* to eastern North America and the abundance of *E. Calendulae* and similar forms in Europe suggest that this group originated in the old world; but the morphological distinction of *E. Davisii* indicates that part, at least, of the invasion of the new world took place early. There may be at least one large-spored group that originated in South America, but available descriptions and material are insufficient to give a clear picture. *E. Compositarum* is probably far commoner in South America than the records suggest. Several species erected by Sydow appear to be indistinguishable from it.

There have been very few reports of species of *Entyloma* attacking members of the Cichoreae in North America. The *North American Flora* lists an early report on *Lactuca canadensis* from Minnesota assigned to *E. Compositarum*, *E. bullulum* on *Sonchus oleracea* from Santo Domingo, a fungus on *Agoseris* from Manitoba assigned to *E. Compositarum*, and *E. Agoseridis* on *Agoseris purpurea* from Colorado. The report on *Agoseris* from Manitoba is based on a collection listed by Bisby, Buller, and Dearness (1). Bisby *et al.* (2) later deleted this record, being in doubt about applying the name *E. Compositarum* to a smut on *Agoseris* and the specimen having been mislaid. This collection was made by Mr. I. L. Conners, at Roblin, Man., 28 July 1927. It was set aside with other specimens that required further study, after Mr. Conners was transferred to Ottawa, and was overlooked until recently. The host has been identified with reasonable certainty as *A. glauca.* The smut has teliospores 8.5–16.7 × 7.2–15.7μ, with walls 0.5–2.5μ, abundant but not

crowded; no conidia or conidiophores could be found. It is assumed to be *E. Agoseridis* Zundel, but the type of that species has not been seen. The relationship of this fungus, the one on *Lactuca*, and the various smuts on Cichoreae in Europe is in doubt. It is the writer's belief that all these forms should be held distinct from any attacking members of the Tubuliflorae. The Sydows' breakdown of the collective species *E. Calendulae* was, as has been shown, without regard to morphological distinction. Several specimens on *Arnoseris* and *Hieracium* that have been examined are very similar to *E. Calendulae* (*sensu stricto*). Even if they are removed from *E. Calendulae* they should probably be regarded as one species, but the Sydows' treatment has made almost any action open to misinterpretation. *E. Picridis* Rostr., as exemplified by Sydow Mycotheca Germanica 776 (Univ. of Toronto) has spores 10.5–17.3 × 8.5–13.5μ, densely crowded, with walls 0.5–2.0μ, and lacks conidia. This species was published in 1877 and may prove to be the best depository for certain forms with spores slightly larger than those of the smuts of *Arnoseris* and *Hieracium*.

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